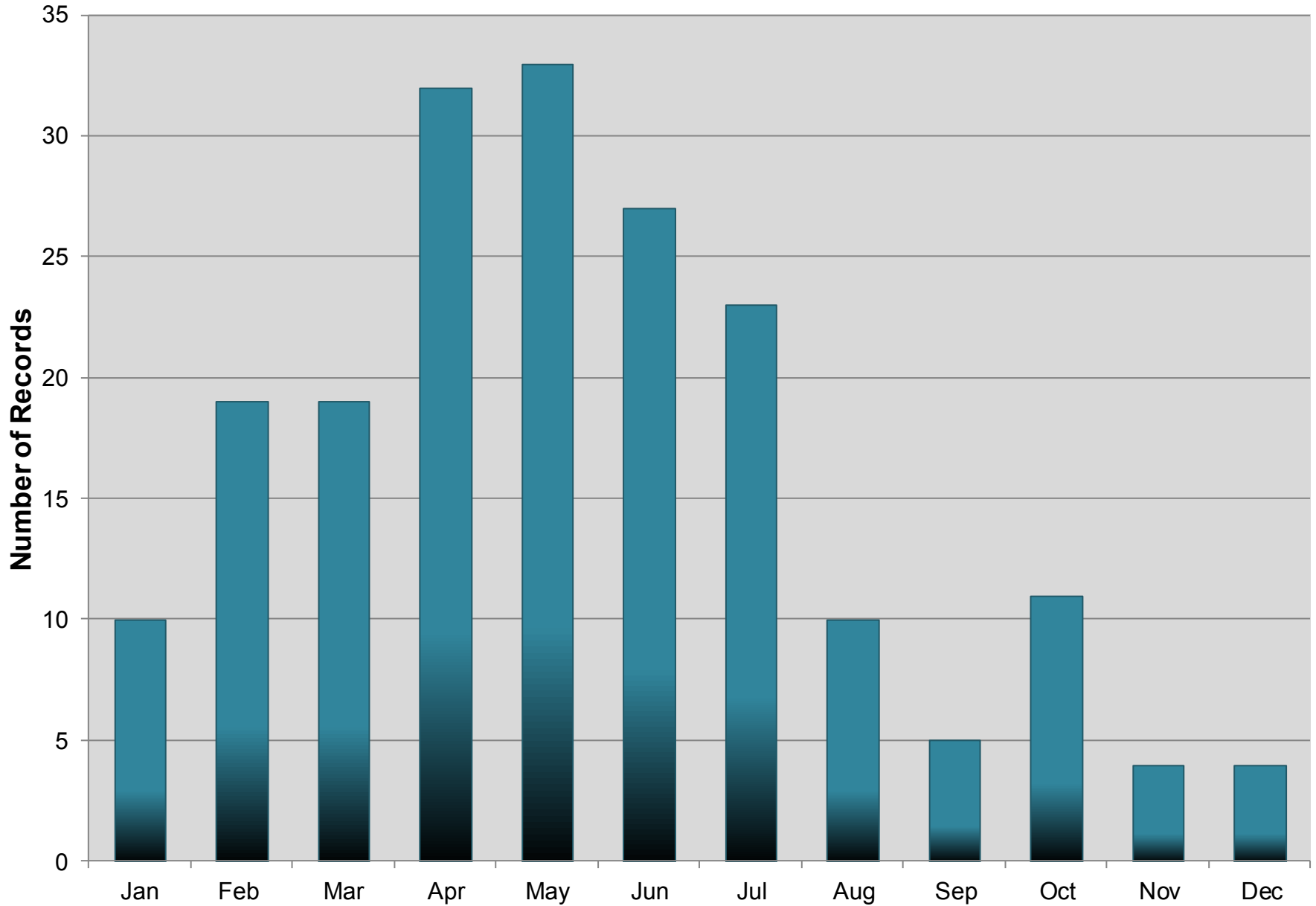


THE INFLUENCES OF OCEANOGRAPHIC AND METEOROLOGICAL FEATURES ON REEF FISH RECRUITMENT IN HAWAI'I

Helen E. Fox, Kelly M. Haisfield, Michael S.
Brown, Todd C. Stevenson, Brian N. Tissot, Ivor
D. Williams, William j. Walsh

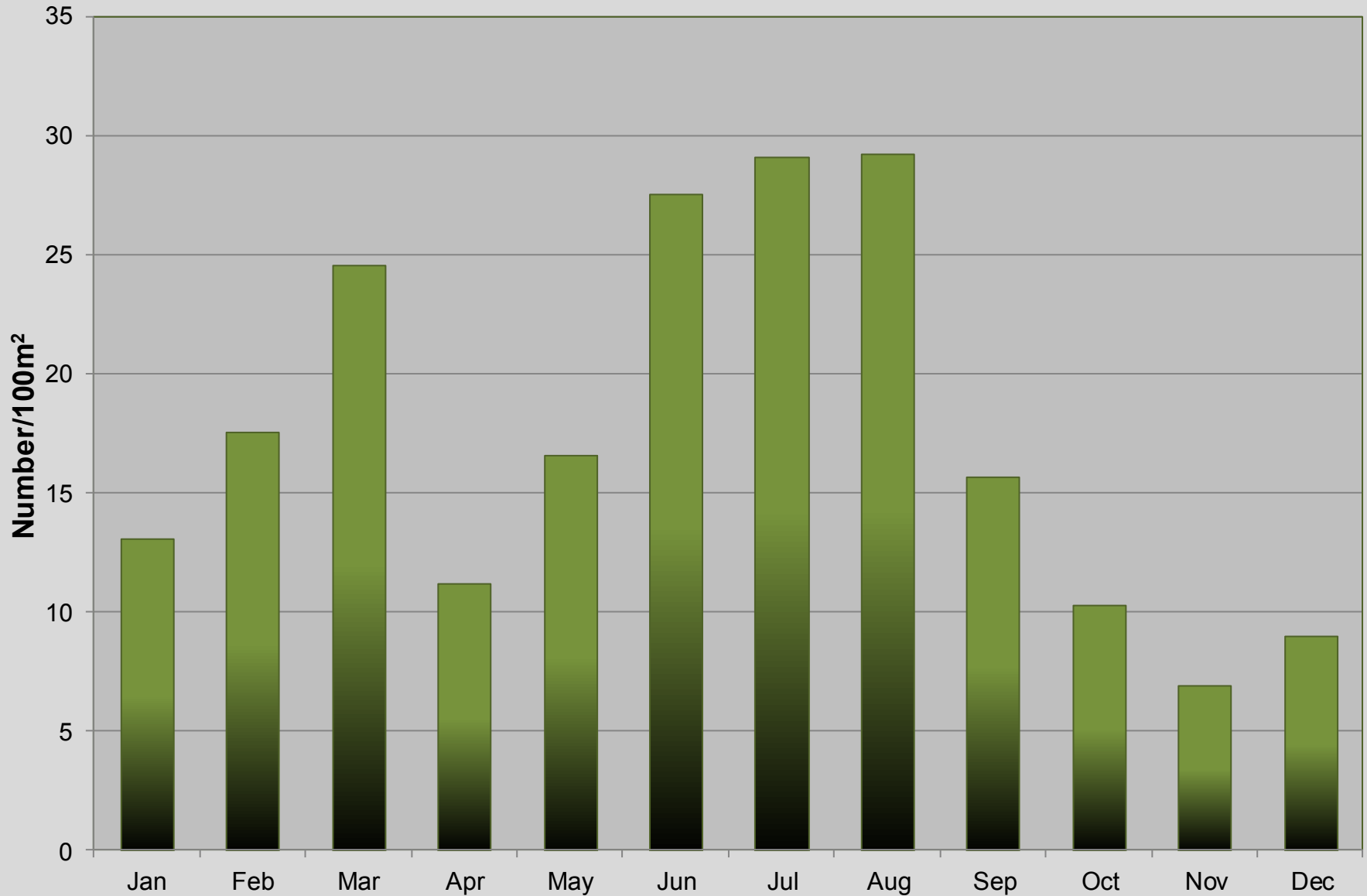
Peak Spawning Months of Hawaiian fishes



~50 spp. – Walsh 1987, Longenecker 2008, Bushnell et al. 2010

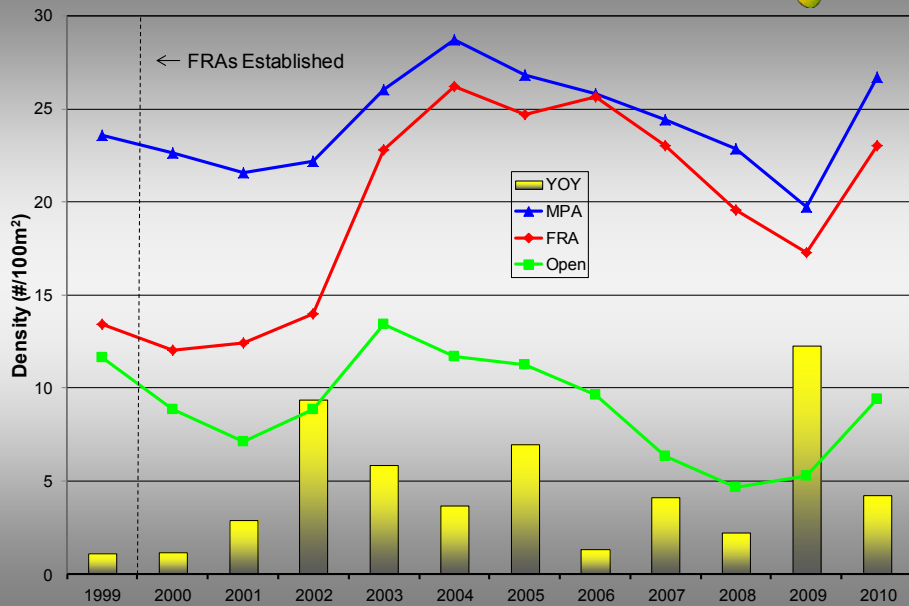
Reef Fish Recruitment at Ke'ei - West Hawai'i

1977-2011

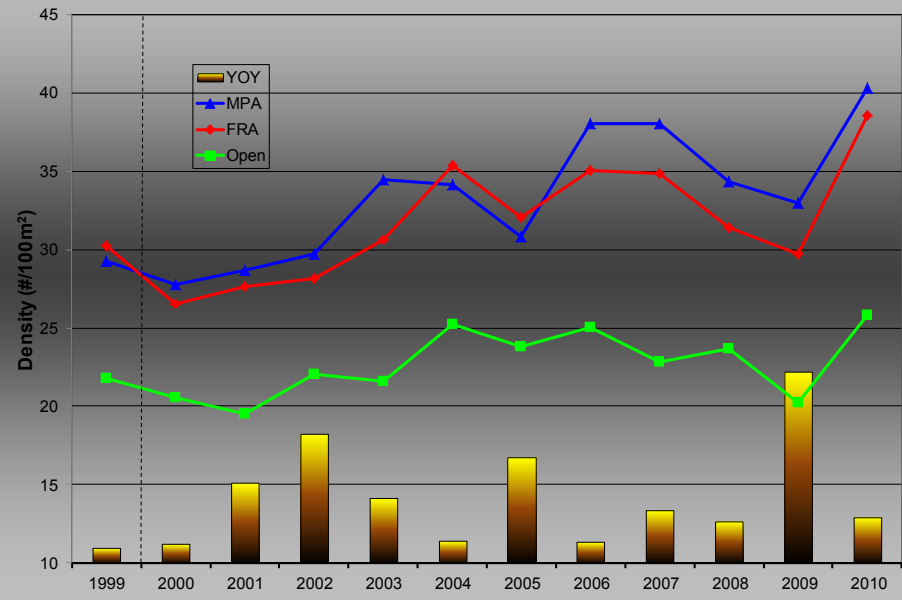


Substantial Interannual Variation in Recruitment

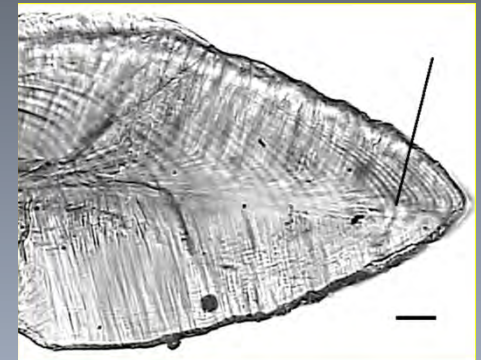
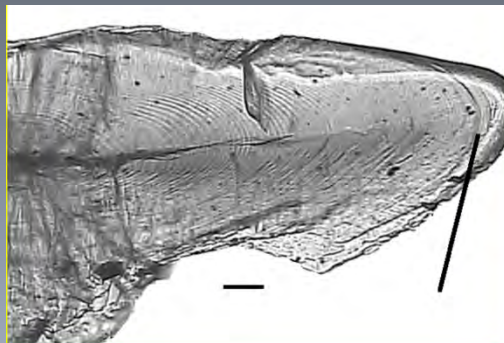
Overall changes in Yellow Tang abundance in FRAs, MPAs and Open areas - 1999-2010



Overall changes in Kole abundance in FRAs, MPAs and Open areas - 1999-2010



Basic Larval/Recruit Biology



~54 days

Larval duration

~60 days

~19 days

Size @ Settlement

~32mm

~43mm

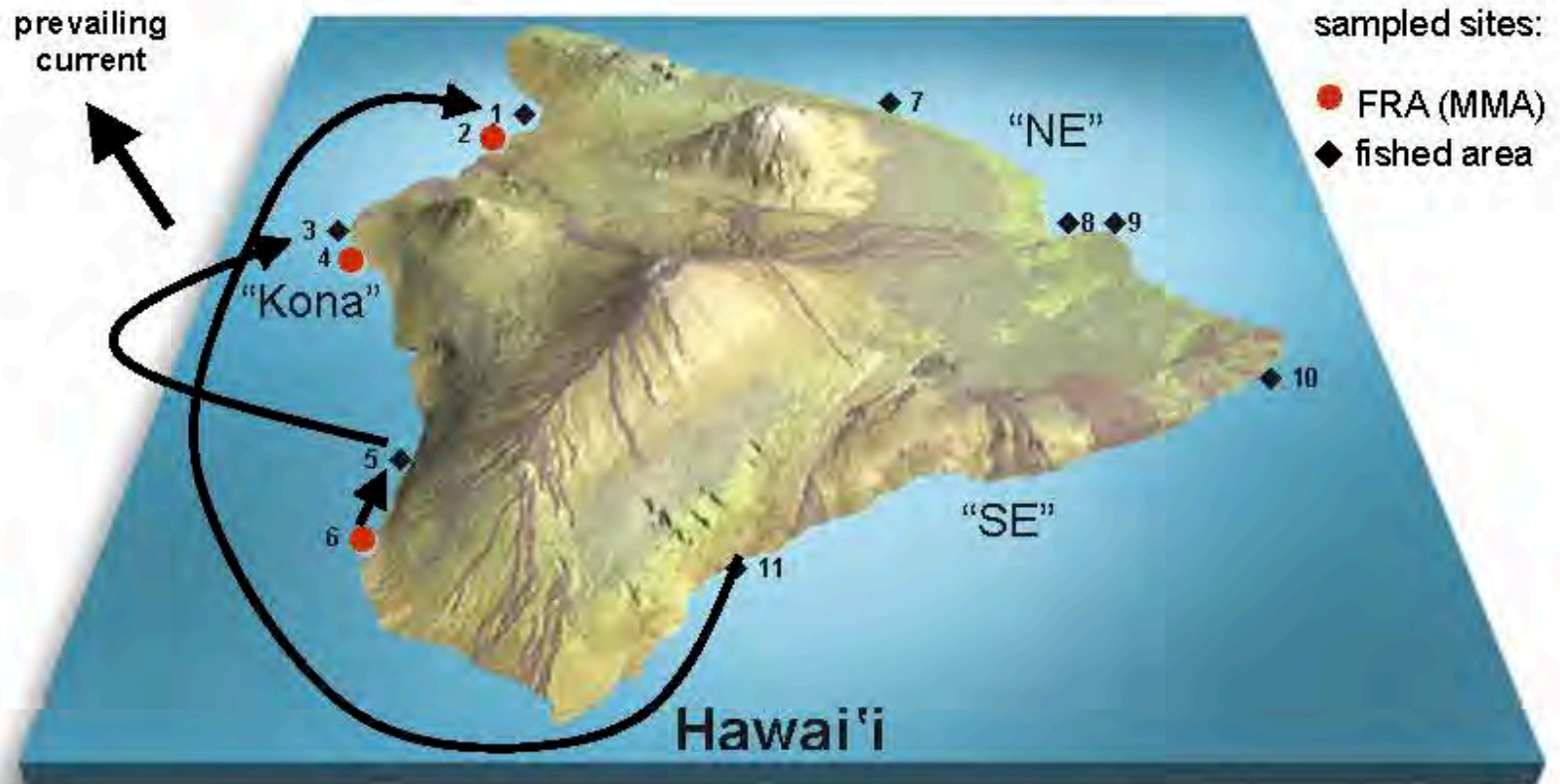
Growth rate

~0.52mm/day

~0.4mm/day

~0.4mm/day

Genetic Analyses



Christie et. al. 2010. Larval Connectivity in an Effective Network of Marine Protected Areas.

MESOSCALE EDDIES & FISH RECRUITMENT



TIMING OF EDDY FORMATION

“In general, the peak period of eddy formation and movement appears to coincide with the peak season of reproduction by Hawaiian fishes.”

(Lobel and Robinson 1983)

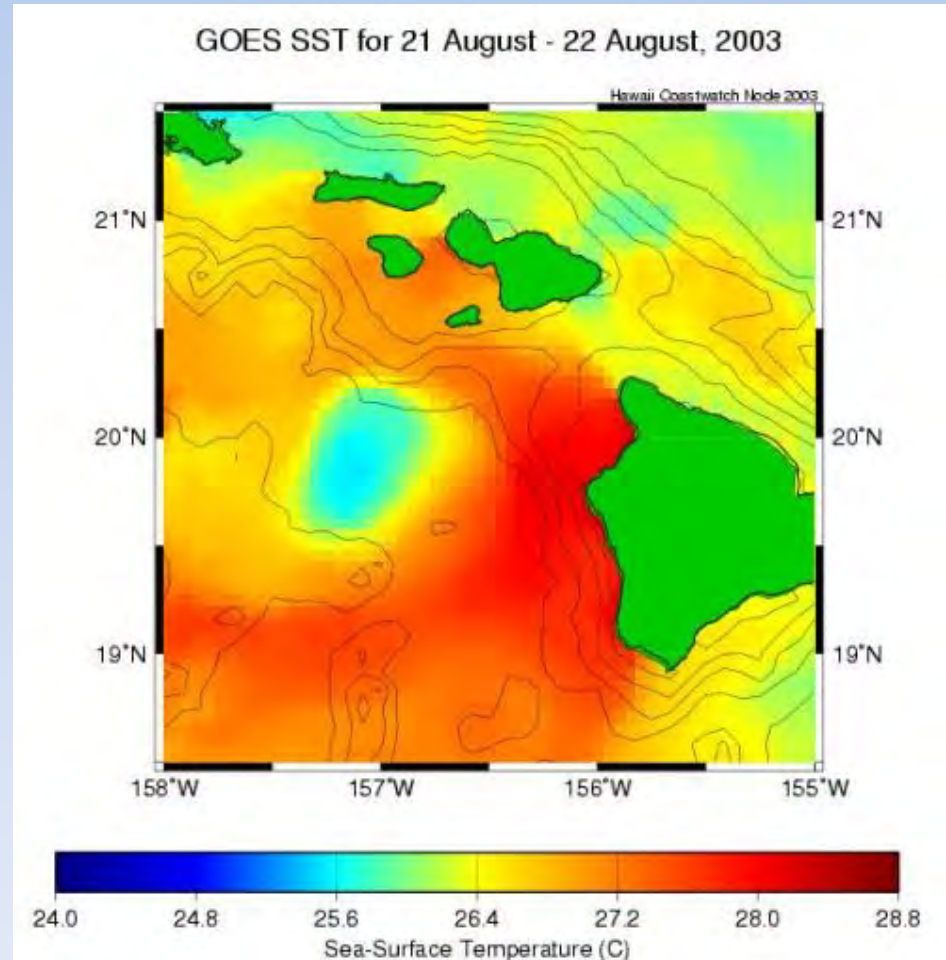
VS.

“the generation of eddies is essentially random” (Flament 1996, The Ocean Atlas of Hawai'i)

HOW MIGHT EDDIES INFLUENCE REEF FISH RECRUITMENT?

Positive: Increase-
nutrients
nearshore retention
survival
recruitment

Negative
increase predators
offshore entrainment
decrease survival
decrease recruitment

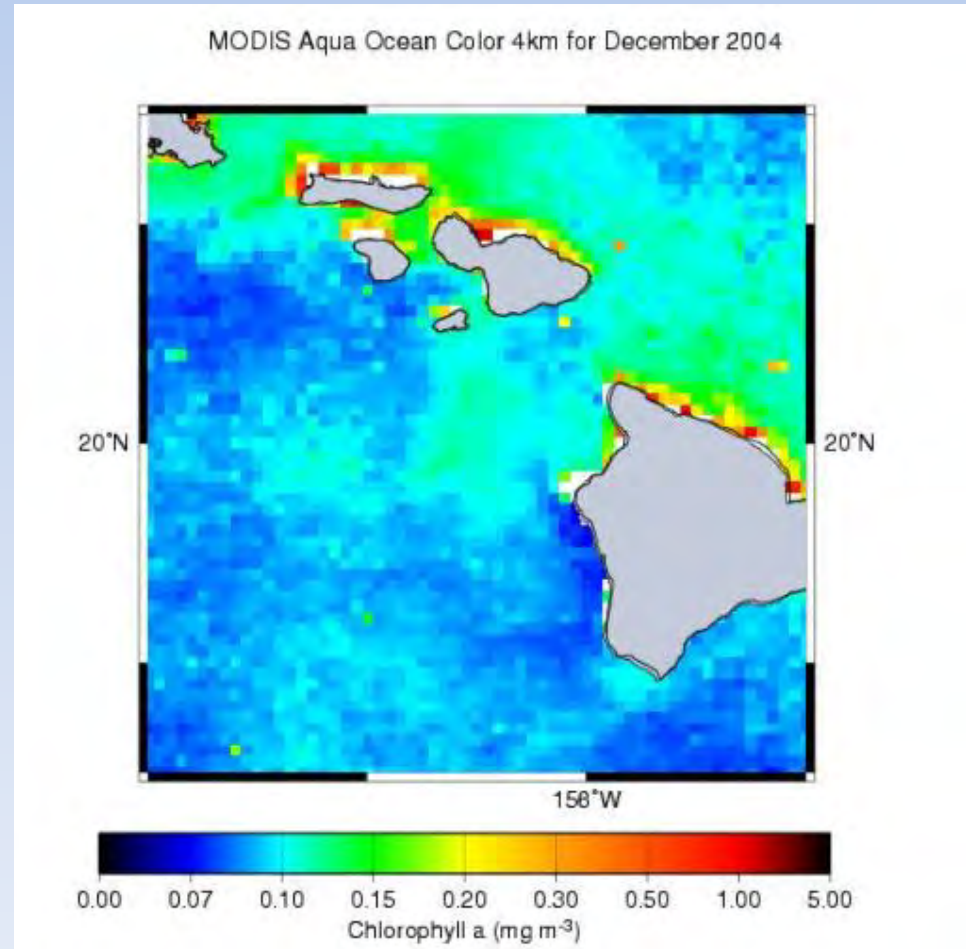


GEOS = Geostationary Operations Environmental Satellite

OTHER POSSIBLE CORRELATES

Fish recruitment correlated with:

- Chlorophyll-a
- Rainfall
- El Niño?



MODIS = Moderate Resolution Imaging Spectrometer Satellite

METHODS: DATA SOURCES



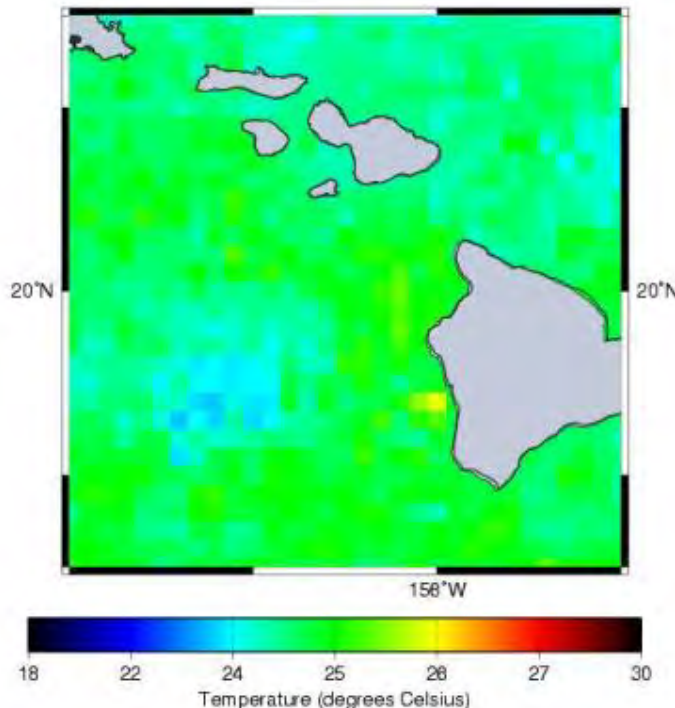
- Fish recruitment data (WHAP)
- Eddies: 8-day and monthly averages of
SST
SSH
Chl-a } (NOAA CoastWatch AVHRR, AVISO, MODIS)
- Rainfall (10 locations NOAA NWS+)
- ONI (Oceanic Niño Index, NOAA)



ANNUAL VARIATION

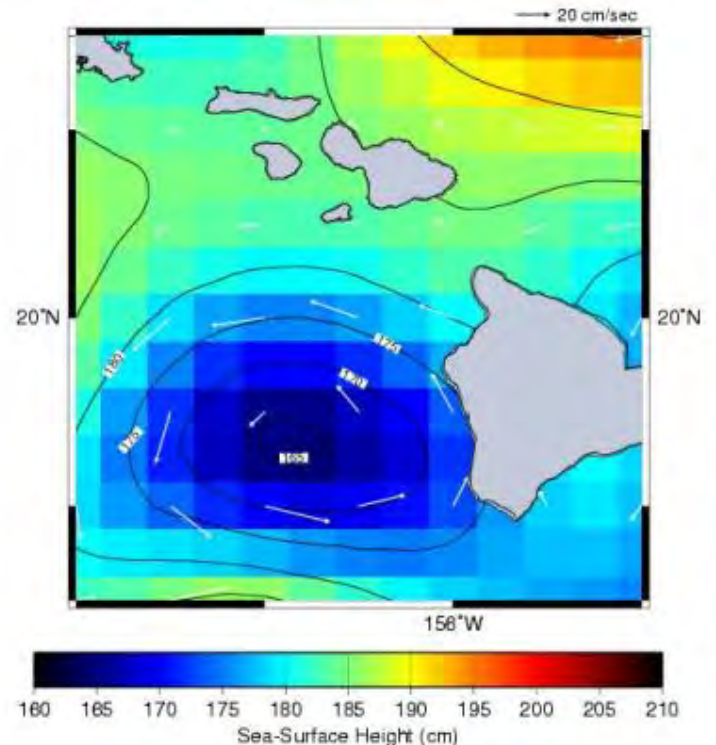
- Fish: YOY totals of 5 most abundant recruiting spp.
- Visual determination of eddy presence, size, location, and intensity based on SST and SSH
- Annual means of Chl-a and rainfall

AVHRR Pathfinder SST from 17 May 2006 to 24 May 2006



Eddy in May
2006 as seen
by
← SST
and SSH →

AVISO Sea-Level Altimetry from 18 May 2006 to 24 May 2006



MONTHLY VARIATION

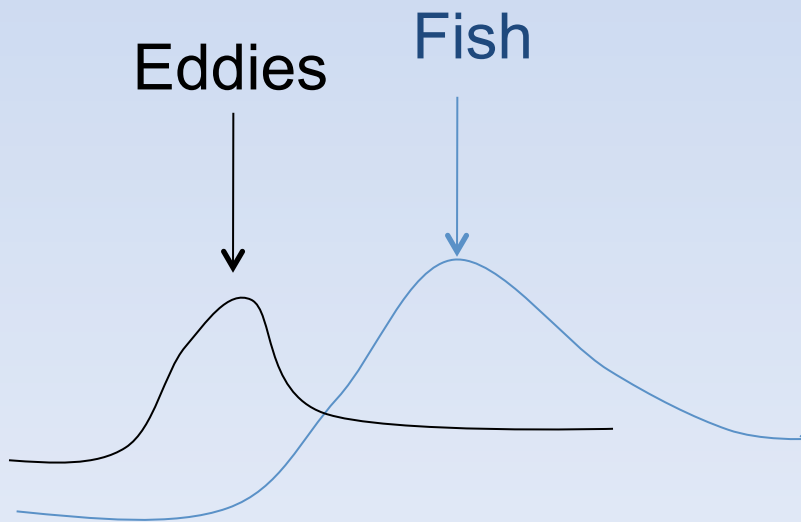
- Fish: recruit data from *Zebrasoma flavescens* and *Ctenochaetus strigosus*, plus all 5 spp.
- Eddy activity
 - Standard deviation (Polovina and Howell 2005)
 - Eddy diameter (M. Brown)
 - Mean monthly SST and SSH
- Mean monthly Chl-a and rainfall
- Oceanic Niño Index

ANALYSIS

Correlations

GLM

Phase Shifts (1 mo-1yr)



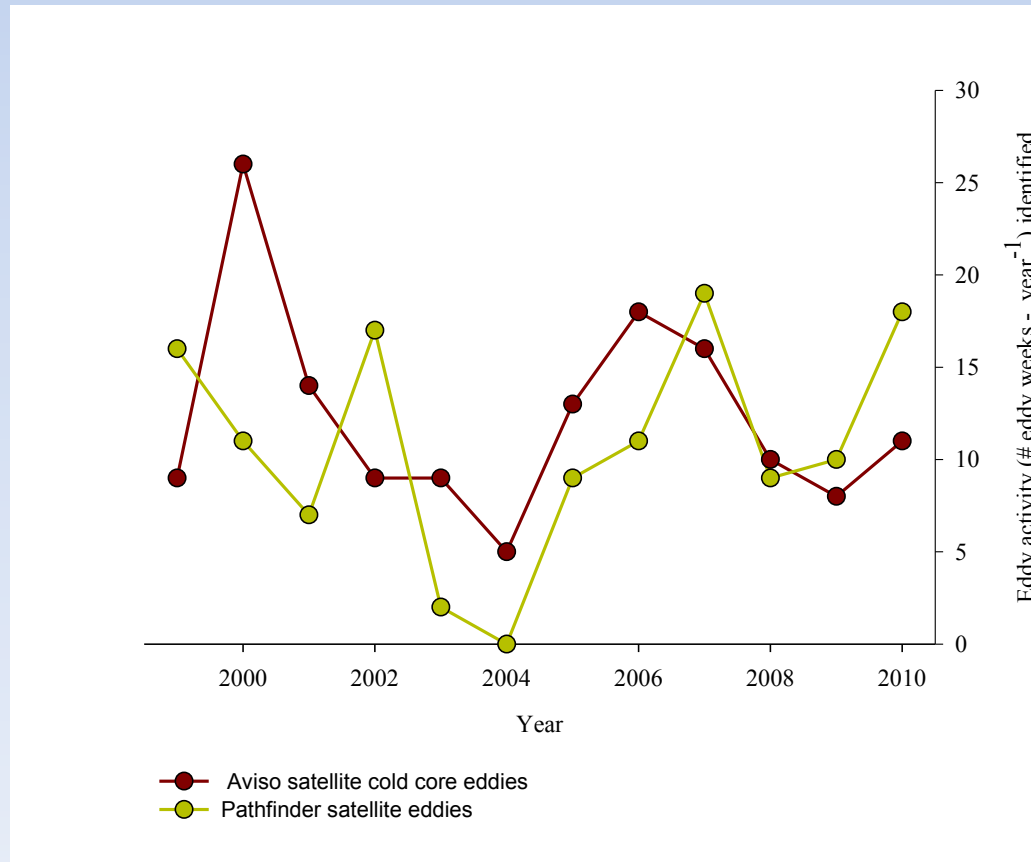
Seasonality

- Patzert's (1969) data re-analyzed with the inclusion of ship days at sea - not accounted for when calculating the number of eddies per season

(Lobel & Robinson 1983, Lobel 1989. Lobel 2011).

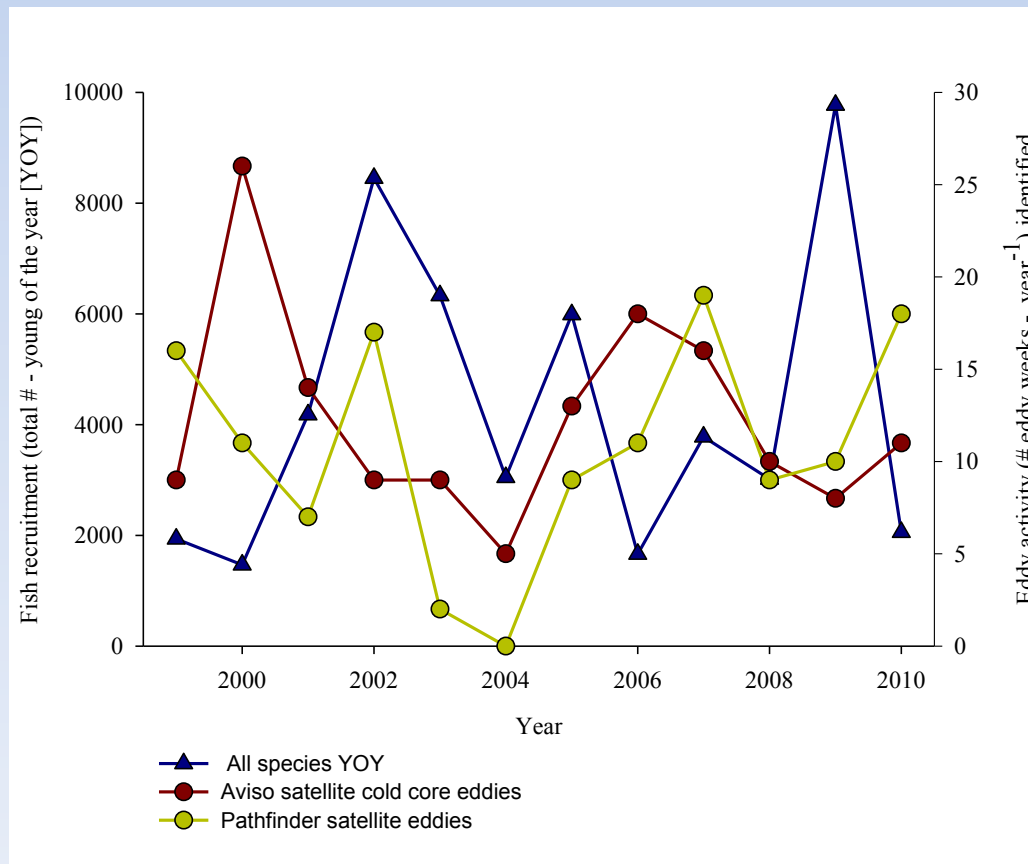
RESULTS: ANNUAL VARIATION

Eddy Activity by Year



RESULTS: ANNUAL VARIATION

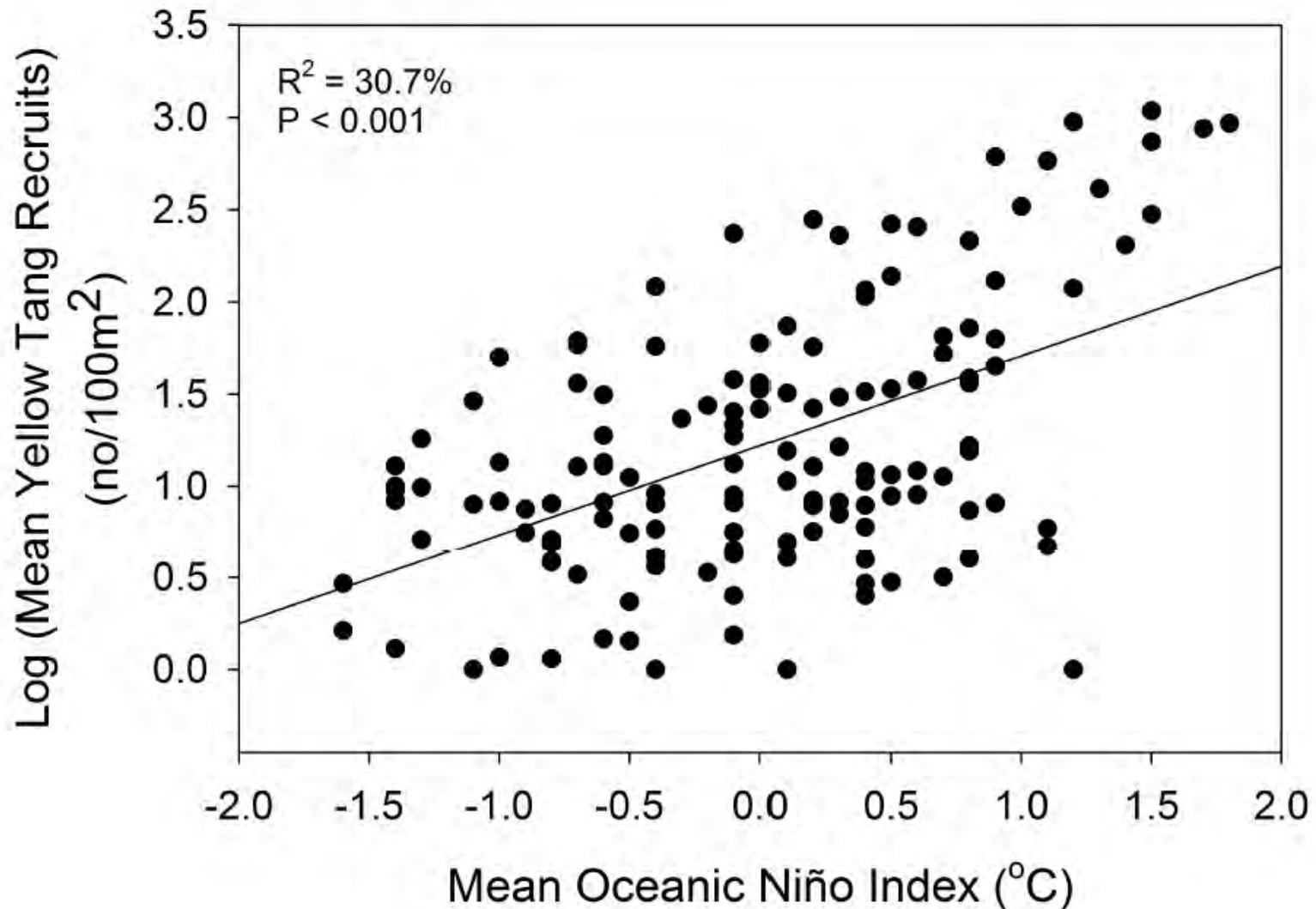
No correlations between YOY & eddy number & intensity
or other variables when examined singly
Negative correlation in GLM w/eddies (SSH) & rainfall



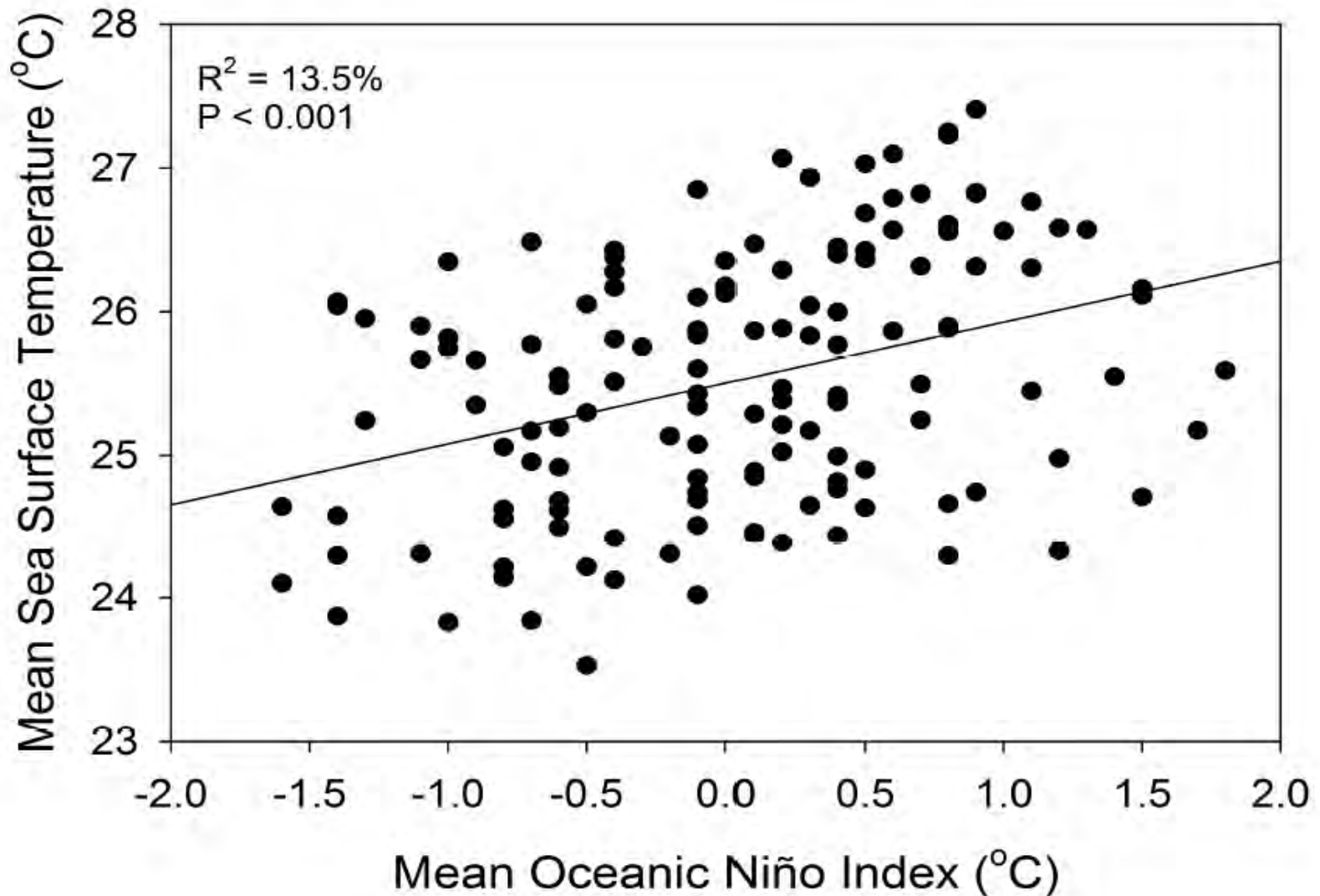
RESULTS: MONTHLY VARIATION

- No significant correlation between monthly recruitment of *Z. flavescens* and *C. strigosus* and eddy activity as measured by standard deviation, eddy diameter, or mean monthly SSH
- Positive correlation with Sea Surface Temperature (no surprise, summer=warmer)
- No correlation with Chl-a (excluding winter bloom) or rainfall

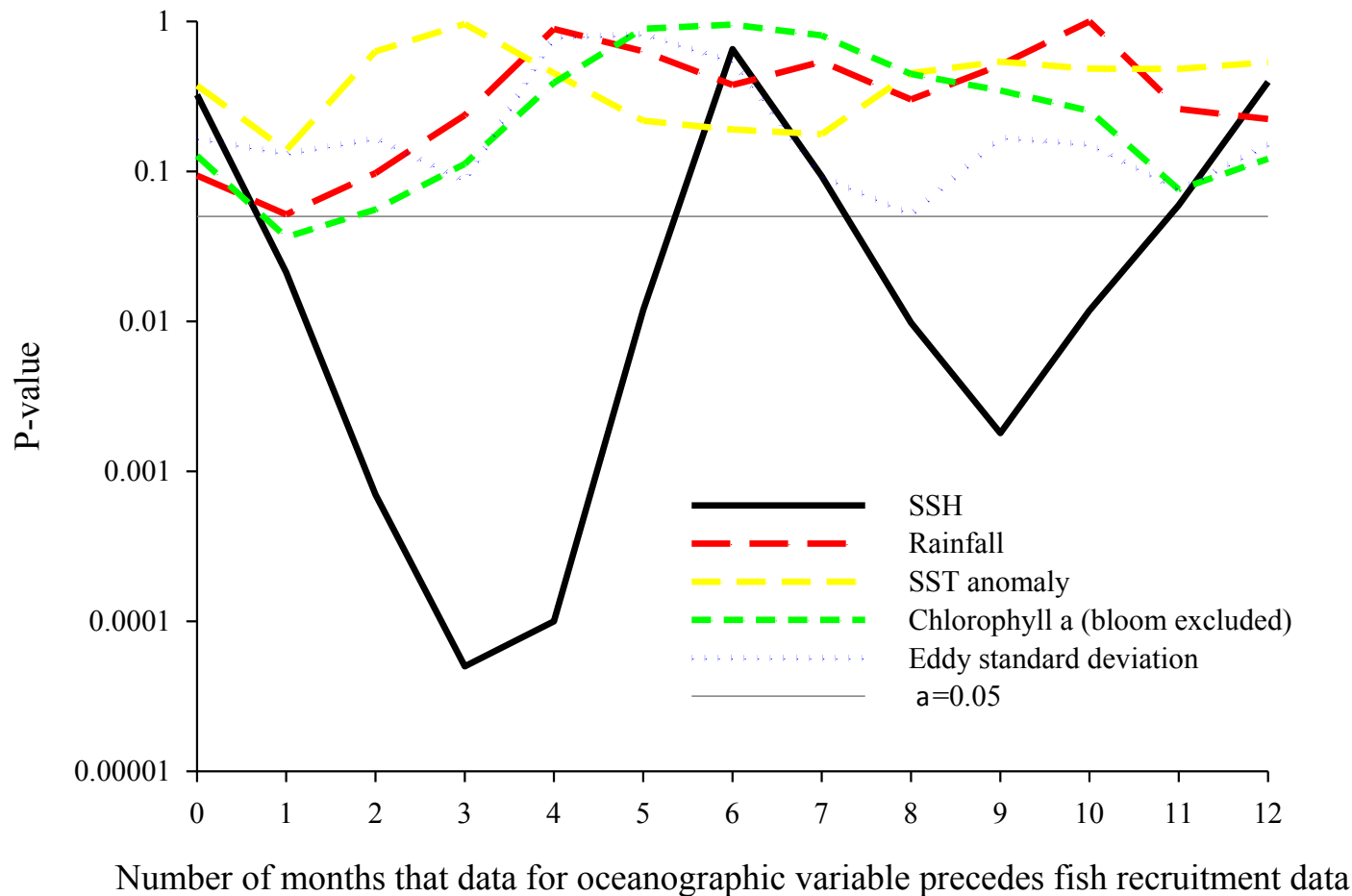
RESULTS: MONTHLY VARIATION



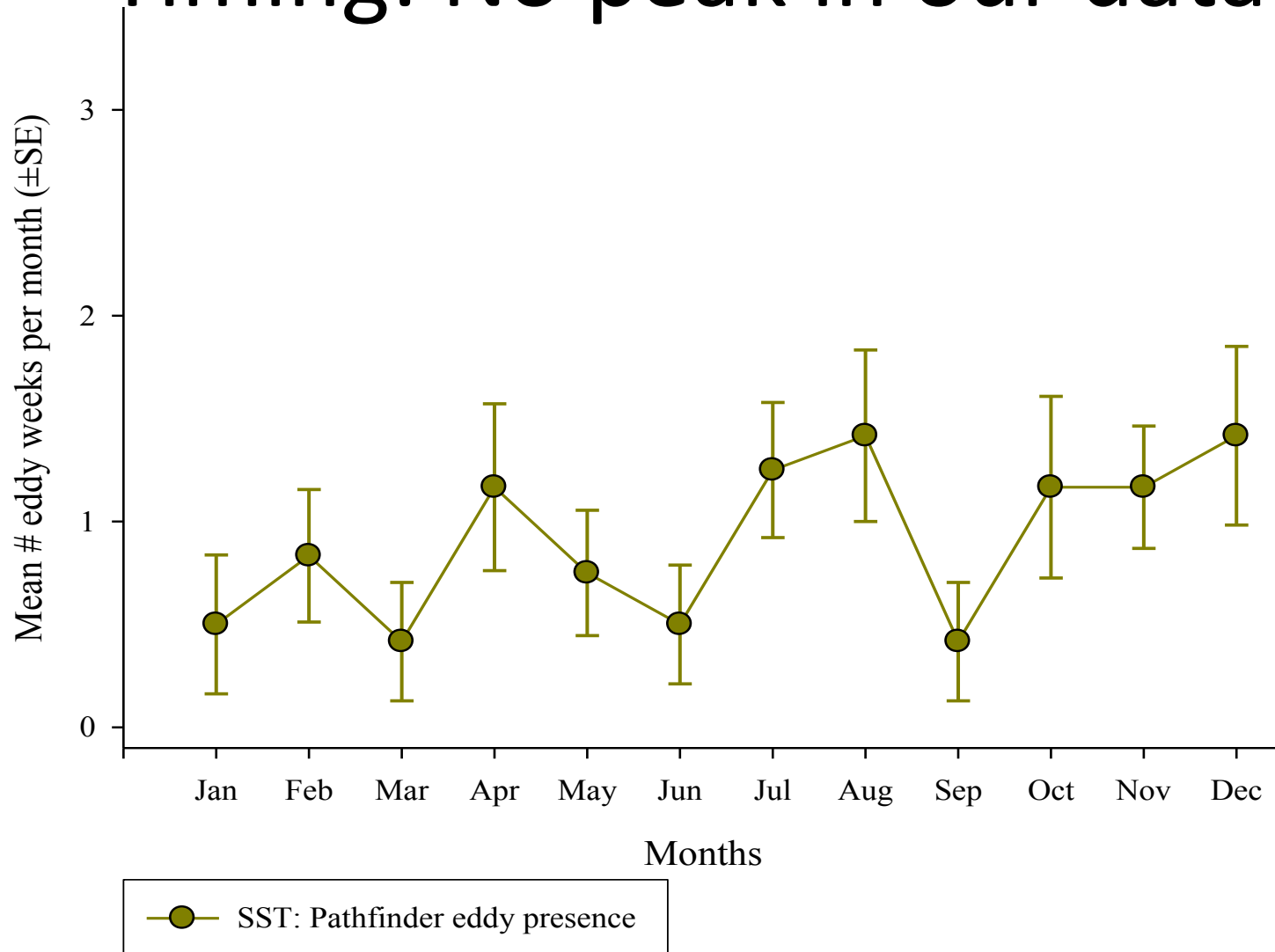
RESULTS: MONTHLY VARIATION



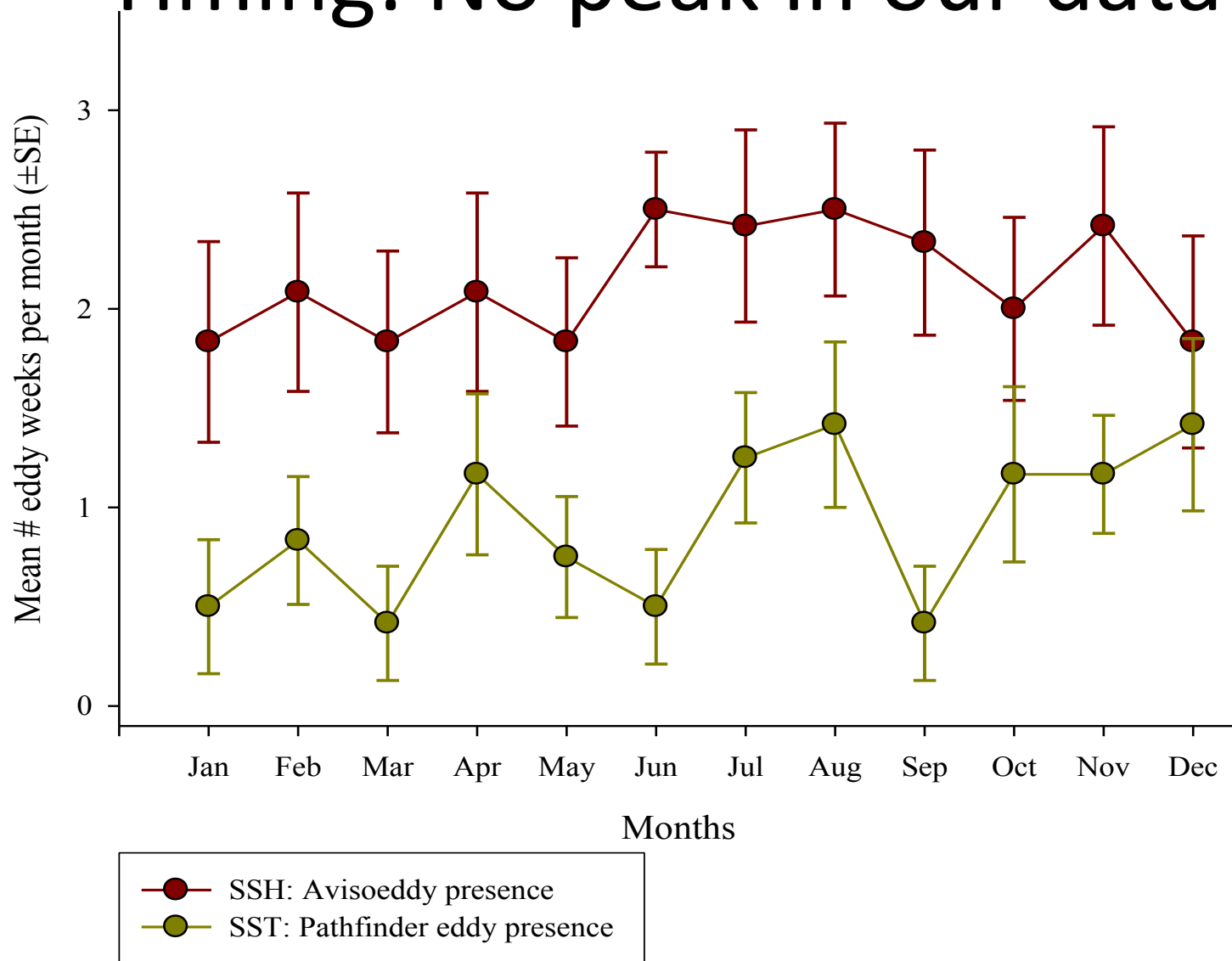
PHASE SHIFT: SSH NEGATIVE 2-5 MONTHS



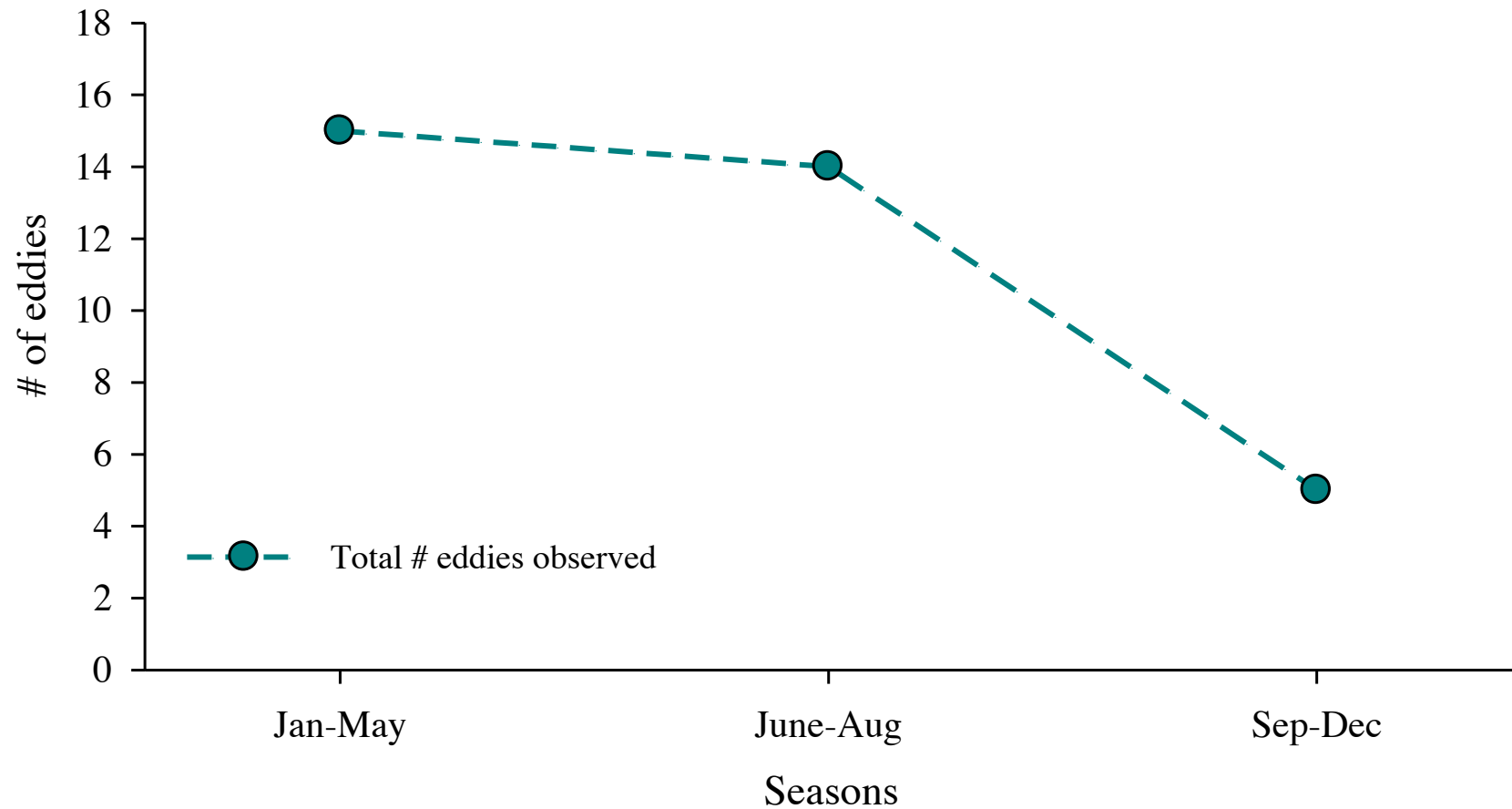
Timing: No peak in our data



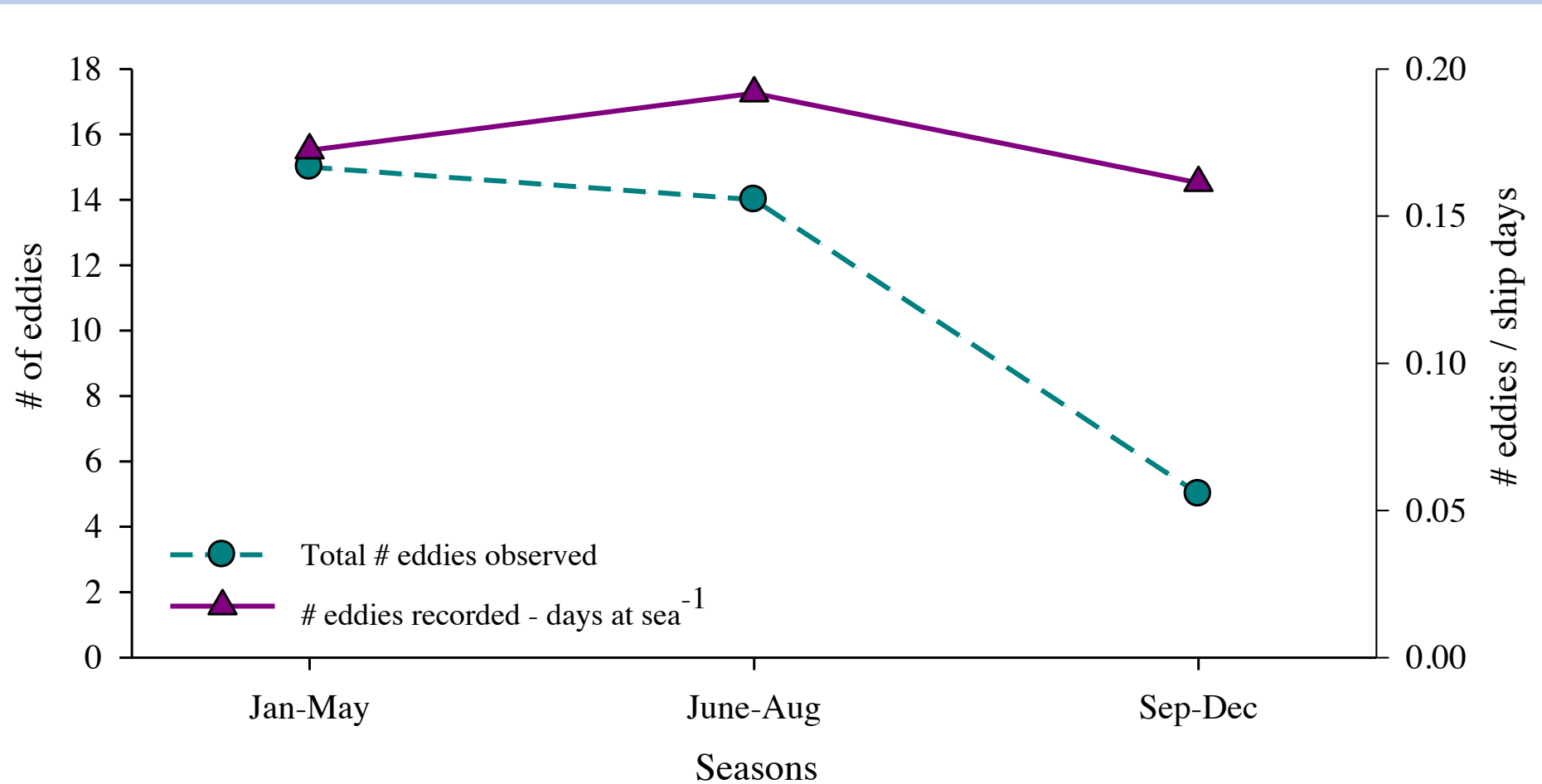
Timing: No peak in our data



RE-ANALYSIS OF PATZERT (1969)



NO PEAK IN RE-ANALYSIS OF PATZERT (1969)



$\chi^2=0.12$, $p=0.94$

CONCLUSIONS

- No conclusive positive linkages between eddy activity, Chl-a or rainfall and fish recruitment either at annual or monthly time scales
- Some suggestion of a negative relationship between YOY and eddy activity 2-5 months prior to recruitment (i.e. larval phase)
- Positive relationship between ONI and yellow tang recruitment but with relatively low predictive value
- No evidence of a spring/summer peak in eddy occurrence in West Hawai'i
- Confirms findings of the unpredictable and highly variable nature of reef fish recruitment

